Ministry of
Northern Development
and Mines
Ontario

Aggregate Resources Inventory of the Town of New Tecumseth Simcoe County

Ontario Geological Survey
Aggregate Resources Inventory
Paper 98

By Staff of the Sedimentary and Environmental Geoscience
Section, Ontario Geological Survey

1992

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ISSN 0708–2061
ISBN 0-7743-7294-X

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Canadian Cataloguing in Publication Data

Main entry under title:

Aggregate resources inventory of the town of New Tecumseth, Simcoe County

(Ontario Geological Survey aggregate resources inventory paper, ISSN 0708–2061; 98)
ISBN 0–7743-7294-X

1. Aggregates (Building materials)--Ontario--New Tecumseth. I. Ontario Geological Survey. Sedimentary and Environmental Geoscience Section. II. Ontario. Ministry of Northern Development and Mines. III. Series.

TN939.A33 1992 553.6'2'0971317 C92–092578–2

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Cette publication est disponible en anglais seulement.

Parts of this publication may be quoted if credit is given. It is recommended that reference be made in the following form:

Ontario Geological Survey 1992. Aggregate resources inventory of the Town of New Tecumseth, Simcoe County; Ontario Geological Survey, Aggregate Resources Inventory Paper 98, 37p.

500–92–Maracle Press

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Abstract

This report includes both an inventory and evaluation of sand and gravel, as well as bedrock resources, in the Town of New Tecumseth in Simcoe County. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under the Aggregate Resources Act.

The Town of New Tecumseth contains very limited resources of crushable gravel. However, sources of sandy aggregate from ice-contact and outwash deposits are abundant. Several of these deposits have been selected for resource protection at the secondary level of significance. These deposits are capable of meeting some local demands for low-specification aggregate uses. Because of the lack of crushable material in the town, high quality aggregate has to be imported to meet many road-building and general construction requirements.

The Town of New Tecumseth is underlain by a succession of Middle and Upper Ordovician strata of the Lindsay, Blue Mountain and Georgian Bay formations. The great thickness of the overlying glacial sediments prevents any of the formations from being selected for possible resource protection.

Selected Resource Areas are not intended to be permanent, single land use units. They represent areas in which a major resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.

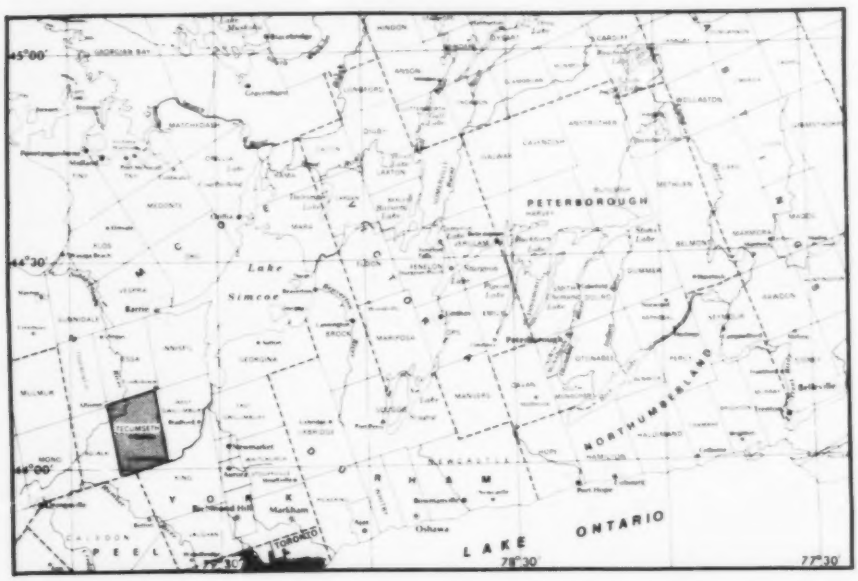


Figure 1. Key map showing the location of the Town of New Tecumseth, Simcoe County, scale 1:1 800 000.

Résumé

Ce rapport comprend un inventaire et une évaluation des dépôts de sable et de gravier aussi bien que des ressources du socle de la ville de New Tecumseth dans le comté de Simcoe. Il s'inscrit dans le programme d'inventaire des ressources en agrégats des municipalités et cantons désignés par la Loi sur les ressources en agrégat.

Les ressources en gravier concassable de la ville de New Tecumseth sont très limitées. Cependant, on y trouve une abondance d'agrégats sableux provenant de dépôts glaciaires et périphériques. On a choisi quelques-uns de ces dépôts pour assurer la protection des ressources d'importance secondaire. Ces dépôts peuvent répondre à certains besoins locaux d'agrégats de basse spécification. En raison du manque de matériel concassable, la municipalité se voit contrainte d'importer des agrégats de haute qualité pour satisfaire à ses besoins en matière de construction générale et routière.

Le soubassement de la ville de New Tecumseth est formé d'une succession de strates d'âge ordovicien moyen et supérieur, qui appartiennent aux formations de Lindsay, Blue Mountain et Georgian Bay. La grande épaisseur des sédiments glaciaires fait qu'on ne peut choisir aucune de ces formations pour la protection possible des ressources.

Les zones sélectionnées pour leurs ressources ne sont pas destinées à un usage unique et permanent. Elles représentent des zones dans lesquelles une ressource importante a été reconnue et peuvent être réservées entièrement ou partiellement pour l'exploitation et/ou comme réserves de ressources.

Cette publication est disponsible en anglais seulement.

Aggregate Resources Inventory of the Town of New Tecumseth

Simcoe County

By Staff[1] of the Sedimentary and Environmental Geoscience Section

1. Project Supervisor: I. Szoke; field work and report by R.G. Gorman; compilation and drafting by Staff of the Aggregate Assessment Office. Assistance with review provided by the Resident Geologist, Ministry of Northern Development and Mines, London, Ontario and the Mineral Resources Staff, Huronia District Office, Ministry of Natural Resources.

Manuscript accepted for publication by Chief, Sedimentary and Environmental Geoscience Section, July 6, 1992. This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1987, the total tonnage of mineral aggregates extracted was 156 million tons (142 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Northern Development and Mines 1989).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of the resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential for bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (*see* References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation, the Ontario Geological Survey and by Regional and District offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, subsurface materials may be assessed by hand augering and test pitting, supplemented by test hole drilling and geophysical surveys using hammer seismic equipment. The symbols for and locations of sample sites, test hole sites and geophysical traverse lines are noted on Map 1.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative layers in these deposits are sampled in 25- to 100-pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analyzed for grain size distribution and in some cases absorption, Los Angeles abrasion and Magnesium Sulphate soundness tests and petrographic analyses are carried out. Analyses are performed either in the laboratories of the Ontario Ministry of Transportation or in the Geoscience Laboratory, Ontario Geological Survey.

The field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation. Data contained in these files include field estimates of the depth, composition and "workability" of deposits, as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size and depth of extraction of pits licenced under the Aggregate Resources Act are obtained from records held by Regional and District offices of the Ontario Ministry of Natural Resources. The co-operation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Aerial photographs at various scales are used to determine the continuity of deposits, especially in areas where information is limited. Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate deposit thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence.

Topographic maps of the National Topographic System, at a scale of 1:50 000, are used as a compilation base for the field and office data. The information is then transferred to a base map, also at a scale of 1:50 000. These base maps are prepared by the Land and Resource Information Branch, Ontario Ministry of Natural Resources with information taken from maps of the National Topographic System by permission of Energy, Mines and Resources Canada, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg/m^3).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e., original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g., wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Resource estimates are calculated for deposits of primary significance. Resource estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps, and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 60 feet (18 m) is used for thickness. Volume estimates are then multiplied by the density factor [the estimated weight in tons of a one-foot (0.3 m) thick section of rock, one acre (0.4 ha) in extent].

Resources of dolostone are calculated using a density factor of 165 pounds per cubic foot (2649 kg/m^3) or 3600 tons per acre (8070 t/ha). Sandstone resources are calculated using a density estimate of 146 pounds per cubic foot (2344 kg/m^3) and shale resources are calculated with a factor of 150 pounds per cubic foot (2408 kg/m^3).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources (*see* Glossary, Appendix B) in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976).

Part II — Data Presentation and Interpretation

Two maps, each portraying a different aspect of the aggregate resources in the town, accompany the report. Map 1, "Sand and Gravel Resources", gives a comprehensive inventory and evaluation of the sand and gravel resources in the report area. Map 2, "Bedrock Resources" shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: SAND AND GRAVEL RESOURCES

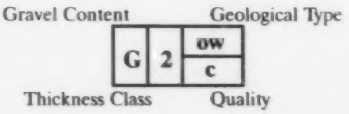
Map 1 shows the extent and quality of sand and gravel deposits within the study area and evaluation of the aggregate resources. The map is derived from existing surficial geology maps of the area or from aerial photograph interpretation in areas where surficial mapping is incomplete.

The present level of extractive activity is also indicated on Map 1. Those areas which are licenced for extraction under the Aggregate Resources Act are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner/operator and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are identified by a numbered dot on Map 1 and described in Table 2. Similarly, test hole locations appear on Map 1 as a point symbol and are described in Table 7. Geophysics lines are shown on Map 1 by a line symbol and are interpreted in Table 8.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type) and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35% gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35% of the whole deposit. "G" indicates that the deposit contains more than 35% gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the deposit types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30% gravel, 60% sand and 10% silt and clay:

Selected Sand and Gravel Resource Areas

All the Selected Sand and Gravel Resource Areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary and tertiary. Each area of primary significance is given a deposit number and all such deposits are shown by dark red shading on Map 1.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units. They represent areas in which a major resource is known to exist, and may be reserved wholly or partially for extractive development and/or resource protection.

Deposits of secondary significance are indicated by medium red shading on Map 1. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quantities of sand and gravel and should be considered part of the aggregate supply of the area.

Areas of tertiary significance are indicated by light red shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1 [greater than 20 feet (6 m) thick] and containing more than 35% gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols on Map 1. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the quality indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35% gravel in addition to a minimum of 20% material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10% may impede drainage in road subbase aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20% oversize material [greater than 4 inches (10 cm) in diameter] may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol shows either "C", "O", or "L" or any combination of these indicators, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt is made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and the Sedimentary and Environmental Geoscience Section of the Ontario Geological Survey, and from field observations.

Quality data may also appear in Table 9, where the results of aggregate quality tests are listed by test type and sample location. The types of tests conducted and the test specifications are explained in Appendixes B and E, respectively.

Analyses of unprocessed samples obtained from test holes, pits or sample sites are plotted on grain size distribution graphs. On the graphs are the Ontario Ministry of Transportation's gradation specification envelopes for aggregate products: Granular Base Course A, B and C, Hot-Laid Asphaltic Sand Nos. 1,2,3,4 and 8, and concrete sand. By plotting the gradation curves with

respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product. These graphs, called Aggregate Grading Curves, follow the tables in the report.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 2: BEDROCK RESOURCES

Map 2 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources) and from geotechnical test hole data from various sources. Map 2 is based on concepts similar to those outlined for Map 1.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of these areas of thin drift are shown by three shades of blue. The darkest shade indicates where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource areas. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas, the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 2 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the Aggregate Resources Act are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner/operator, licenced acreage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 2 and described in Table 5. Two additional symbols may appear on the map. An open dot indicates the location of a selected water well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot. Similarly, test hole locations appear as a point symbol with the depth to bedrock shown in feet beside it. The test holes may be further described in Table 7.

Selection Criteria

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

Selected Resource Areas

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 2 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 2 are not permanent, single land use units. They represent areas in which a major bedrock resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.

Part III — Assessment of Aggregate Resources of the Town of New Tecumseth

LOCATION AND POPULATION

The Town of New Tecumseth occupies an area of 65 945 acres (26 688 ha) in southern Simcoe County. The town is shown at a scale of 1:50 000 on the Alliston (31 D/4) and Bolton (30 M/13) map sheets of the National Topographic System.

The population of the Town of New Tecumseth was 19 282 in 1991 (Ontario Ministry of Municipal Affairs 1992). The majority of the residents are rural-farm or rural-residential inhabitants. Smaller communities include Colgan and Nicolston. The former town of Alliston and the former villages of Tottenham and Beeton serve as the main regional trade and retail centres.

The town is served by a grid network of paved and gravel-surfaced town and county roads. King's highways 9 and 89 border the town and serve as haulage routes to market centres. Lines of the Canadian Pacific Railway serve the area.

The Town of New Tecumseth was officially amalgamated in January of 1992. This report does not include a small part of the former town of Alliston which was mapped prior to this amalgamation and was included in the Aggregate Resources Inventory Papers for Adjala Township and Essa and Tosorontio townships (Ontario Geological Survey 1980, 1988).

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and surficial geology of the Town of New Tecumseth is largely the result of glacial activity which took place during the Late Wisconsinan Substage of the Pleistocene Epoch (informally known as the "Great Ice Age"). Approximately 23 000 years ago, lobes or submasses of the Laurentide Ice Sheet advanced out of the Great Lakes basins and covered southern Ontario. These ice lobes underwent numerous fluctuations until approximately 12 000 years ago when the ice wasted back into the lake basins. The landforms and distribution of surficial materials in the town, and specifically the sand and gravel deposits shown on Map 1 of this report, are the result of ice margin fluctuations of the Lake Simcoe ice lobe.

The Town of New Tecumseth covers an area which includes 4 physiographic regions: Simcoe lowlands, Peterborough drumlin field, Schomberg clay plains and the Oak Ridges moraine (Chapman and Putnam 1984).

A portion of the Simcoe lowlands occupies most of the northern half of the town. Much of the material in this area consists of fine-grained glaciolacustrine sediments. A small part of the Peterborough drumlin field is located in the far northern part of the town. The few drumlins present are generally separated by glaciolacustrine sediments deposited in glacial Lake Algonquin. A large part of the southern half of the town is covered by clay of the Schomberg clay plain (Deane 1950; Chapman and Putnam 1984). Much of the remaining material is glaciofluvial outwash and ice-contact stratified drift. The latter material overlies a drumlinized moraine, south of the former village of Tottenham. This moraine was considered to be part of the Oak Ridges moraine when it was mapped on a regional scale by Chapman and Putnam (1984), however, Gwyn and White (1973) and White (1975), who mapped the area at a more detailed scale, did not consider these sediments to be part of the Oak Ridges moraine.

Two tills found within the Town of New Tecumseth were deposited by the southward and southwestward flowing Lake Simcoe ice lobe (Gwyn 1972). These tills are overlain and separated by glaciolacustrine, outwash and ice-contact stratified materials.

The oldest till unit in the town is the Newmarket Till (Gwyn 1972). The material is a light yellowish brown sand to compact silty sand till (Gwyn and White 1973). This till forms the surface material for a substantial area of the town. The till also occurs as prominent isolated hills such as Rich Hill, southeast of the former village of Tottenham. The till may contain appreciable percentages of pebbles and boulders as observed in pit no. 6 (Map 1). Newmarket Till is an unsuitable source of aggregate because of its excess fines content, however, it has been used in bridge abutments in the town (Gwyn and Clue 1976).

During the subsequent retreat of the ice margin, ice-contact stratified drift, glaciofluvial outwash and early Lake Schomberg glaciolacustrine materials were deposited. The ice-contact and outwash deposits, located south of the former village of Beeton, generally contain silty fine to medium sand with scattered bodies of crushable gravel. The deposits are sources of fine aggregate mainly suitable for low-specification products. However, some of the sandy material is acceptable for most high-specification fine aggregate products, such as concrete and asphalt sand, with suitable processing.

While the Lake Simcoe ice lobe retreated even further, meltwaters ponded between the retreating ice margin and higher ground to the south (Putnam and Chapman 1936; Gwyn 1972) thus producing the early Lake Schomberg Ponds. The materials deposited in these water bodies consist of a series of silts and clayey silts (Gwyn 1972; White 1975).

Later readvances of the Lake Simcoe lobe to the south-southwest overrode the early Schomberg sediments and deposited the Kettleby Till in two phases (Gwyn 1972). This light brown, clayey silt to silt till commonly caps hills in the town (Gwyn and White

1973; White 1975). The Kettleby Till contains up to 80% silt- and clay-sized material (Hewitt and White 1969) and, therefore, is unacceptable for any road-building or construction products.

With the final retreat of the Simcoe lobe northward, deposits of the late Lake Schomberg Ponds were laid down over the Kettleby Till. These deposits of well-stratified sand with lesser amounts of silt and varved silt and clay (Gwyn and White 1973; White 1975) comprise the surficial material in the area from the former town of Alliston to the former village of Beeton and northeastward to the former village of Cookstown. The fine-grained sand and silt are susceptible to frost heave and break-up, therefore, limiting their potential as local aggregate resources.

Postglacial erosional and depositional processes have been of minor importance in modifying the landscape in the Town of New Tecumseth. Isolated deposits of peat, muck and marl are situated in lowland areas. Deposits of older and modern fine-grained alluvium are also common in the lowland areas where rivers and streams have cut into the glaciolacustrine sediments. A single windblown deposit of fine-grained silty sand is located west of the former village of Beeton.

EXTRACTIVE ACTIVITY

Extractive activity in the Town of New Tecumseth is generally centred in the sandy outwash and ice-contact deposits located south of the former village of Beeton. At the time of writing, 6 sand and gravel pits were licenced to operate under the Aggregate Resources Act. The licenced properties have a total area of 253.9 acres (102.7 ha). Many of the remaining unlicenced pits are overgrown and abandoned.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 illustrates the occurrence of sand and gravel deposits in the Town of New Tecumseth. Most of the material found in the town has low potential for use as road-building or construction aggregate. The lack of coarse granular material prevents any deposits from being selected at the primary level of significance. However, a large deposit of ice-contact stratified drift, part of which is buried, and a glaciofluvial outwash deposit located in the southern half of the town have been selected for possible resource protection at the secondary level of significance.

Resource Areas of Secondary Significance

An area of ice-contact stratified drift, located south of the former village of Tottenham (Map 1), has been selected at the secondary level of significance. This deposit extends westward into Adjala Township and southward into the Town of Caledon and King Township where it eventually extends into the Palgrave Moraine (White 1975). This deposit exhibits a well-developed, knob and kettle topography (Gwyn and White 1973). Faces in pit nos. 7, 8 and 9 exposed fine to medium sand to silty sand. Crushable aggregate is of minor occurrence, although isolated pockets of coarse aggregate were noted in pit no. 9. A test hole (TC-TH-2), located northeast of Rich Hill, revealed 22 feet (7 m) of fine to medium sand with traces of gravel (Table 7). Samples of the material indicate that the gravel content is less than 10% and it is generally suitable for Granular Base Course (GBC) C (Figure 2a). The fine to medium sand has only limited potential for asphalt and concrete sand (Figure 2b) unless suitable processing is employed.

An area of buried sand and gravel, that is a subsurface continuation of the above-mentioned ice-contact stratified drift deposit, has been tentatively identified by Gwyn and Clue (1976) in the Rich Hill area (Map 1). The geological boundary is generalized and is based primarily on water well data that indicate a surface till overlying sand and/or gravel. Pit no. 1 is located in this buried deposit and its southern face revealed approximately 10 feet (3 m) of brown silty till overlying pebbly medium to coarse sand. A test hole (TC-TH-1), located in the floor of the pit, revealed 18 feet (6 m) of pebbly coarse sand (Table 7). Samples of aggregate from the test hole contained approximately 7% gravel, 92% sand and 1% fines (Figures 2a and 2b). The grain size distribution for this sample lies within acceptable limits for GBC B and C, and should be suitable for most high-specification fine aggregate products. A geophysics traverse line (TC-GT-1) completed on the floor of pit no. 1 (Map 1) indicated the presence of an additional 14 feet (4 m) of sand and gravel (Table 8).

A small deposit of glaciofluvial outwash, located northeast of the former village of Tottenham, has also been selected at the secondary level of significance. There are two licenced properties (pit nos. 2 and 3) located in the deposit. Pit faces ranged from 15 to 30 feet (5 to 9 m) in height and exposed gravel contents ranging between 20 and 40%. Faces in both pits were partially overgrown, however, in places they exposed stratified fine to coarse sand and fine gravel.

BEDROCK GEOLOGY AND RESOURCE POTENTIAL

The Town of New Tecumseth is underlain by a succession of Middle and Upper Ordovician strata of the Lindsay, Blue Mountain and Georgian Bay formations. These units occur in sequence from the oldest in the northeast corner of the town, to the youngest in the southwest (Map 2).

In the map area, the thickness of surficial drift overlying the bedrock is generally in excess of 200 feet (61 m) and northeast of Rich Hill the drift cover exceeds 400 feet (122 m). Quarrying of the bedrock units in this area, therefore, is not practical. For this reason, none of the bedrock has been selected for resource protection.

The oldest bedrock unit in the Town of New Tecumseth is the Lindsay Formation. The formation underlies a large area in the northern and eastern parts of the town. The formation consists of two members: the lower member is a grey, argillaceous, very fine- to coarse-crystalline limestone containing numerous shaly partings, particularly in the upper portion of the unit (Derry Michener Booth and Wahl and Ontario Geological Survey 1989); and the upper Collingwood Member (Russell and Telford 1983) is brownish black, organic-rich, interbedded calcareous shale and limestone. The formation is generally unsatisfactory for use as concrete aggregate and probably for less demanding aggregate uses as well (Dolar-Mantuani 1975). The lower member has, however, been quarried elsewhere for use as a raw material in cement production. Shale of the Collingwood Member may have special value for the production of expanded aggregate (Guillet and Joyce 1987).

Shale of the Blue Mountain Formation occurs in a continuous band across the town. The unit overlies the Lindsay Formation and consists of blue-grey noncalcareous shale. This formation is generally not suitable for the production of concrete or load-bearing aggregate. Test data, however, indicate that the shale has good potential for the production of expanded aggregate (Guillet and Joyce 1987).

The youngest bedrock unit in the town is the Georgian Bay Formation. The formation consists of shales with interbeds of siltstone and limestone and occupies the southern and southwestern parts of the town. This unit has been used extensively for brick manufacture in the Toronto area and has also been used for some forms of heat-expanded lightweight aggregate in the past (Guillet and Joyce 1987). However, it has little value for load-bearing uses such as road aggregate.

SUMMARY

The sand and gravel deposits of the Town of New Tecumseth are primarily the product of glacial activity that occurred during the Late Wisconsinan Substage of the Pleistocene Epoch. Presently, proven resources of crushable material are scarce in the town. In the past, ice-contact and outwash deposits have supplied sandy aggregate capable of meeting local demands for low-specification uses. Because of the general lack of crushable material in the town, only resource areas of secondary significance have been selected for possible resource protection. Care should be taken to ensure the continued availability of as much of these resource areas as possible.

Bedrock units underlying the Town of New Tecumseth include the Lindsay, Blue Mountain and Georgian Bay formations. Thick drift restricts any of the formations from being selected for possible resource protection. The town must rely on imported crushed stone products for road-building and general construction purposes.

Enquiries regarding the Aggregate Resources Inventory of the Town of New Tecumseth should be directed to the Sedimentary and Environmental Geoscience Section, Ontario Geological Survey, Ontario Ministry of Northern Development and Mines, 933 Ramsey Lake Road, Sudbury, Ontario, P3E 6B5, or to the Resident Geologist, Ministry of Northern Development and Mines, Box 5463, 659 Exeter Road, London, Ontario, N6A 4L6 [Tel. (519) 661-2773], or to the Ontario Ministry of Natural Resources, Huronia District Office, Midhurst, Ontario, L0L 1X0 [Tel. (705) 728-2900].

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, THE TOWN OF NEW TECUMSETH*.

1 CLASS NO.	2 DEPOSIT TYPE (*see* Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G–IC	50 (20)	4 (4)
	G–OW	105 (42)	7 (6)
	S–IC	3200 (1300)	240 (218)
	S–IC (buried deposit)	540 (218)	27 (24)
	S–OW	1450 (590)	72 (65)
2	G–IC	15 (6)	< 1 (< 1)
	S–LP	19 800 (8000)	740 (670)
	S–OW	1610 (650)	60 (54)
3	G–OW	5 (2)	< 1 (< 1)
4	S–OW	5 (2)	< 1 (< 1)
	S–WD	15 (6)	< 1 (< 1)
TOTAL FOR STUDY AREA:		27 000 (10 900)	1150 (1050)

* *Identified deposit areas within the former town of Alliston and the former villages of Tottenham and Beeton have been omitted on all tables.*

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2. SAND AND GRAVEL PITS, TOWN OF NEW TECUMSETH.

1 NO.	2 MTO NO.	3 OWNER/OPERATOR	4 LICENCED AREA Acres (Hectares)	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL
LICENCED PITS					
1	-	Central Building Supply and Gravel Inc.	37.6 (15.2)	10–20 (3–6)	< 10
2	A4–2	G.E. Elmer	17.0 (6.9)	25–30 (8–9)	20–40
3	A4–59	861651 Ontario Inc.	32.7 (13.2)	15–25 (5–8)	20–40
4	-	Town of New Tecumseth	55.6 (22.5)	10–12 (3–4)	< 20
5	A4–82	L. Wray	70.0 (28.3)	10–20 (3–6)	10
6	A4–6	R.D. Bray	21.0 (8.5)	20–30 (6–9)	variable
TOTAL LICENCED AREA:			253.9 (102.7)		
UNLICENCED PITS*					
7	-	-	-	15–40 (5–12)	< 5 partially overgrown
8	-	-	-	5–10 (1.5–3)	< 5
9	B10–150	Irving–Underman (Clarke–Kitchen)	-	10–50 (3–15)	0–20 variable, partially overgrown
10	-	-	-	10 (3)	20–35 variable
11	-	Town of New Tecumseth	-	10–15 (3–5)	< 20
12	A4–89	Hughes	-	10–15 (3–5)	< 10 largely depleted, partially overgrown
13	-	-	-	20–30 (6–9)	< 10 partially overgrown
14	-	-	-	20 (6)	< 10 partially overgrown
15	-	-	-	10–15 (3–5)	variable
16	A4–8	Leach	-	20–40 (6–12)	30–40 largely depleted
17	-	-	-	8 (2)	< 10

* *Abandoned pits or wayside pits operating on demand under authority of a permit.*

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWN OF NEW TECUMSETH.

- N O N E -

TABLE 4. TOTAL IDENTIFIED BEDROCK RESOURCE AREAS, TOWN OF NEW TECUMSETH.

- N O N E -

TABLE 5. QUARRIES, TOWN OF NEW TECUMSETH.

- N O N E -

TABLE 6. SELECTED BEDROCK RESOURCE AREAS, TOWN OF NEW TECUMSETH.

- N O N E -

TABLE 7. SUMMARY OF TEST HOLE DATA, TOWN OF NEW TECUMSETH.

Test Hole Number: TC–TH–1

Location: Pt. N1/2 Lot 9, Conc. 2 (drilled in floor of pit no. 1)
Town of New Tecumseth

Elevation: Approximately 975 feet (297 m) asl

Date: June 15, 1982

DEPTH feet (metres)	DESCRIPTION
0–5 (0–1.5)	clean, pebbly coarse sand; water table encountered at 5 feet (1.5 m)
5–18 (1.5–6)	wet pebbly coarse sand test hole terminated at 18 feet (6 m)

Test Hole Number: TC–TH–2

Location: Lot 11, Conc. 2
Town of New Tecumseth

Elevation: Approximately 950 feet (290 m) asl

Date: June 15, 1982

DEPTH feet (metres)	DESCRIPTION
0–5 (0–1.5)	clean fine to medium sand
5–11 (1.5–3)	fine to medium sand
11–20 (3–6)	medium sand < 10% fine gravel
20–22 (6–7)	medium sand, clay encountered test hole terminated at 22 feet (7 m)

Test Hole Number: TC–TH–3

Location: Lot 11, Conc. 2
Town of New Tecumseth

Elevation: Approximately 925 feet (282 m) asl

Date: June 15, 1982

DEPTH feet (metres)	DESCRIPTION
0–7 (0–2)	brown silty till test hole terminated at 7 feet (2 m)

Test Hole Number: TC–TH–4

Location: Lot 12, Conc. 4
Town of New Tecumseth

Elevation: Approximately 850 feet (259 m) asl

Date: June 17, 1982

DEPTH feet (metres)	DESCRIPTION
0–5 (0–1.5)	clean fine to medium sand < 10% fine gravel test hole terminated on boulder at 5 feet (1.5 m)

Test Hole Number: TC–TH–5

Location: Lot 12, Conc. 6 (drilled in floor of pit no. 11)
Town of New Tecumseth

Elevation: Approximately 1000 feet (305 m) asl

Date: June 17, 1982

DEPTH feet (metres)	DESCRIPTION
0–8 (0–2)	clean fine sand
8–11 (2–3)	clean fine sand minor clay present
11–20 (3–6)	fine sand test hole terminated at 20 feet (6 m)

TABLE 8. SUMMARY OF GEOPHYSICS DATA, TOWN OF NEW TECUMSETH.

Line Number: TC-GT-1

Line Direction: Northeast

Method: Hammer seismic

Location: Pt. N1/2 Lot 9, Conc. 2 (completed on floor of pit no. 1)

Elevation: Approximately 975 feet (297 m) asl

Seismic Data:
Number of layers: 3
Layer Velocities: V_1 = 1300 ft/sec (395 m/s)
V_2 = 2800 ft/sec (850 m/s)
V_3 = 6100 ft/sec (1860 m/s)

Layer Thickness: D_1 = 3 feet (1 m)
D_2 = 11 feet (3 m)

Interpretation: Approximately 3 feet (1 m) of dry sand overlying approximately 11 feet (3 m) of wet pebbly sand overlying till.

TABLE 9. RESULTS OF AGGREGATE QUALITY TESTS, TOWN OF NEW TECUMSETH.

- NONE -

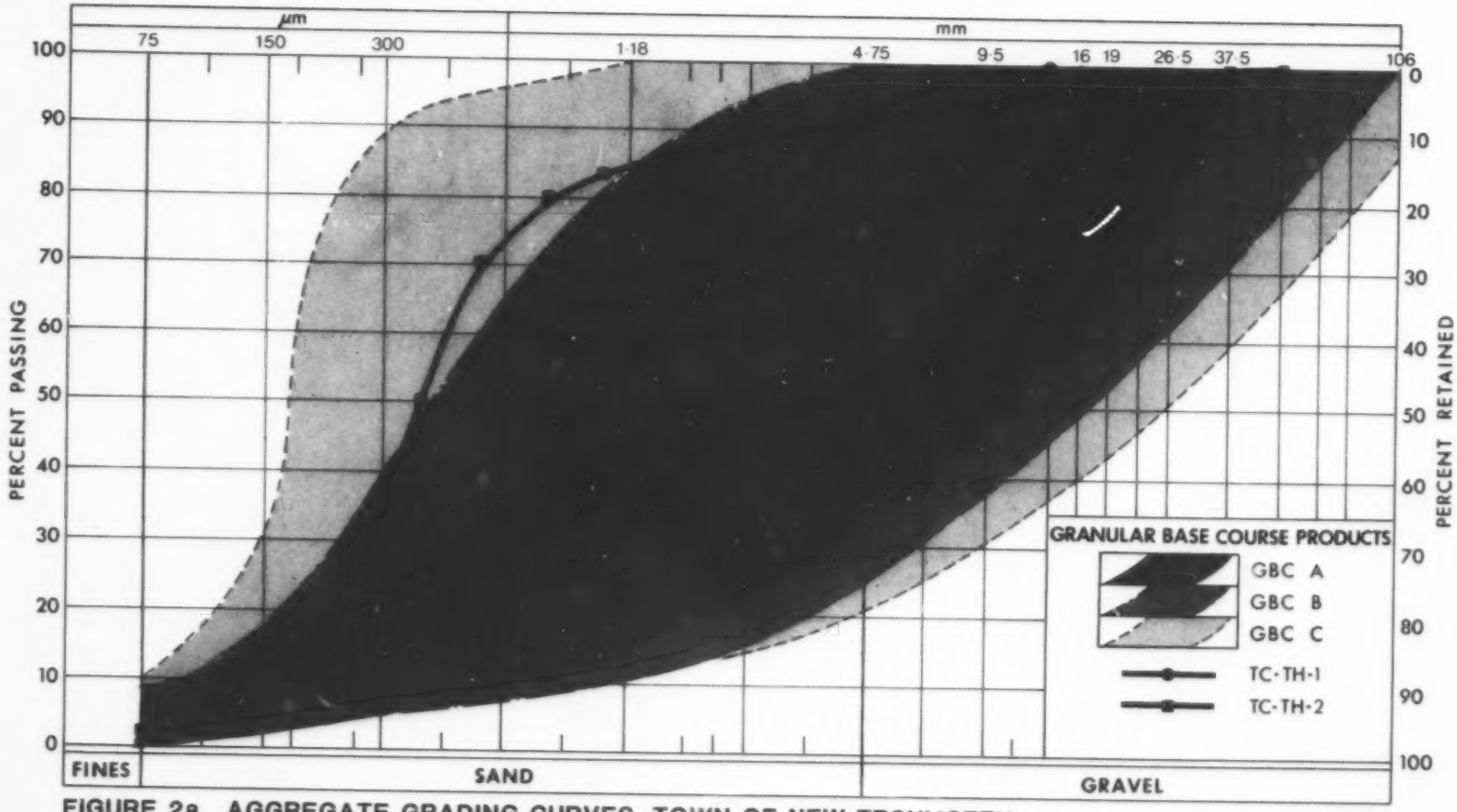


FIGURE 2a. AGGREGATE GRADING CURVES, TOWN OF NEW TECUMSETH.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.O. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

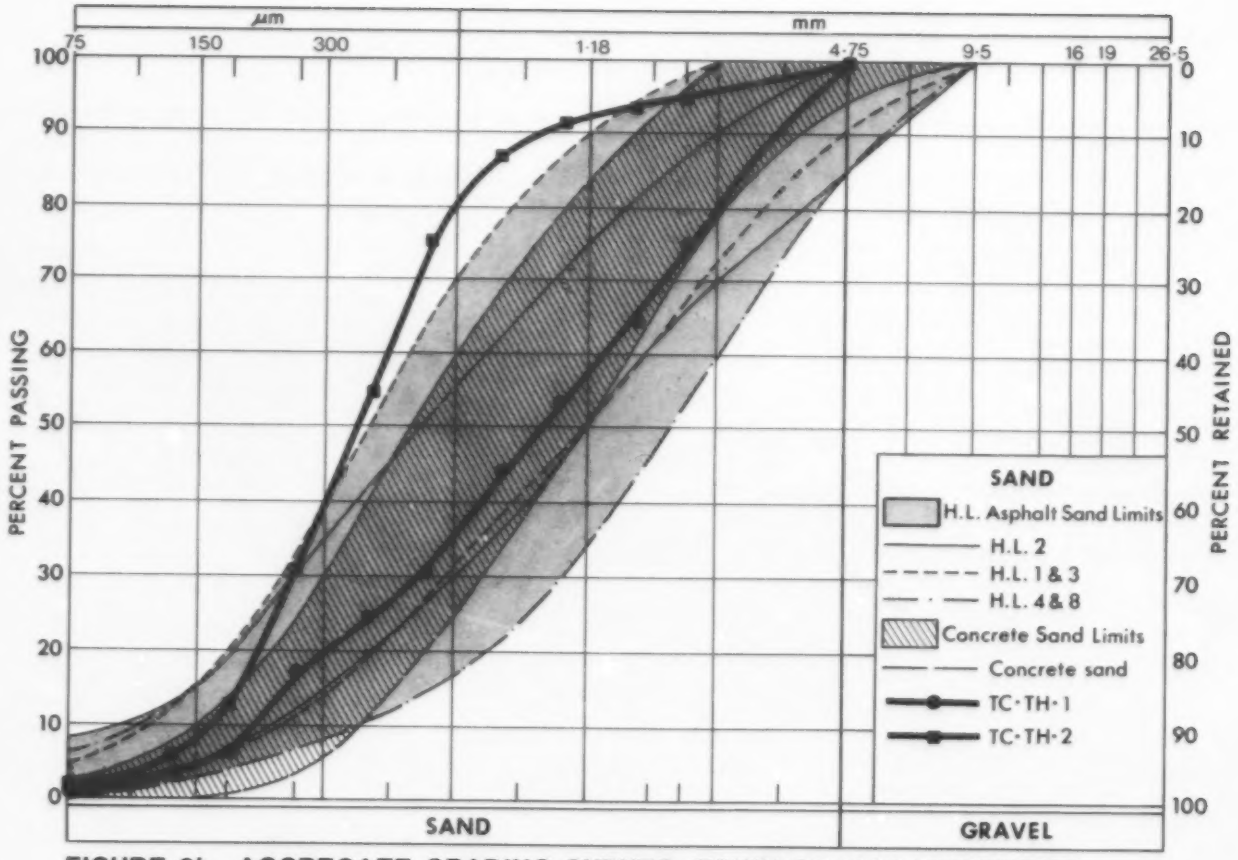


FIGURE 2b. AGGREGATE GRADING CURVES, TOWN OF NEW TECUMSETH.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from MTO Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

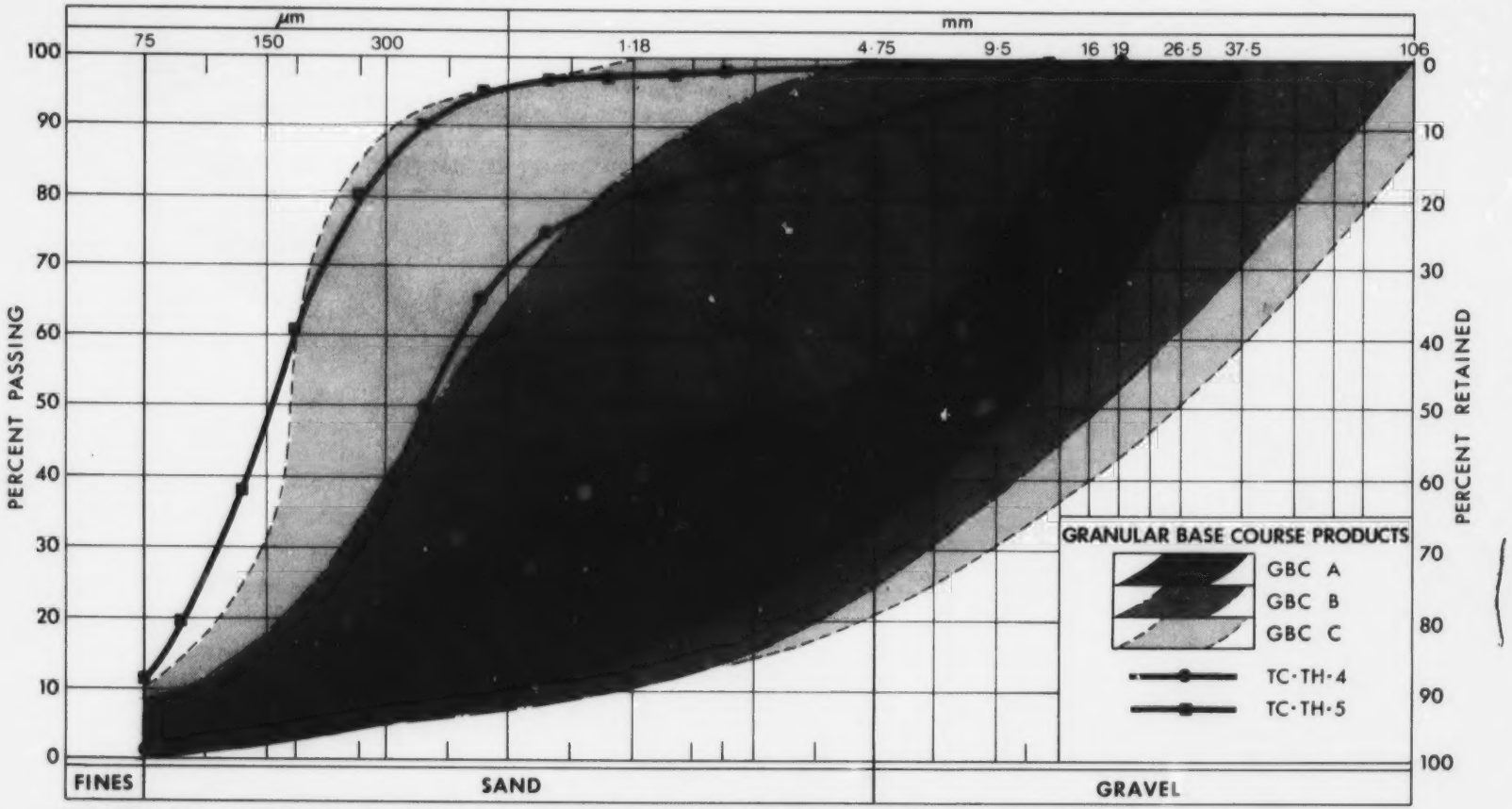


FIGURE 3a. AGGREGATE GRADING CURVES, TOWN OF NEW TECUMSETH.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.O. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

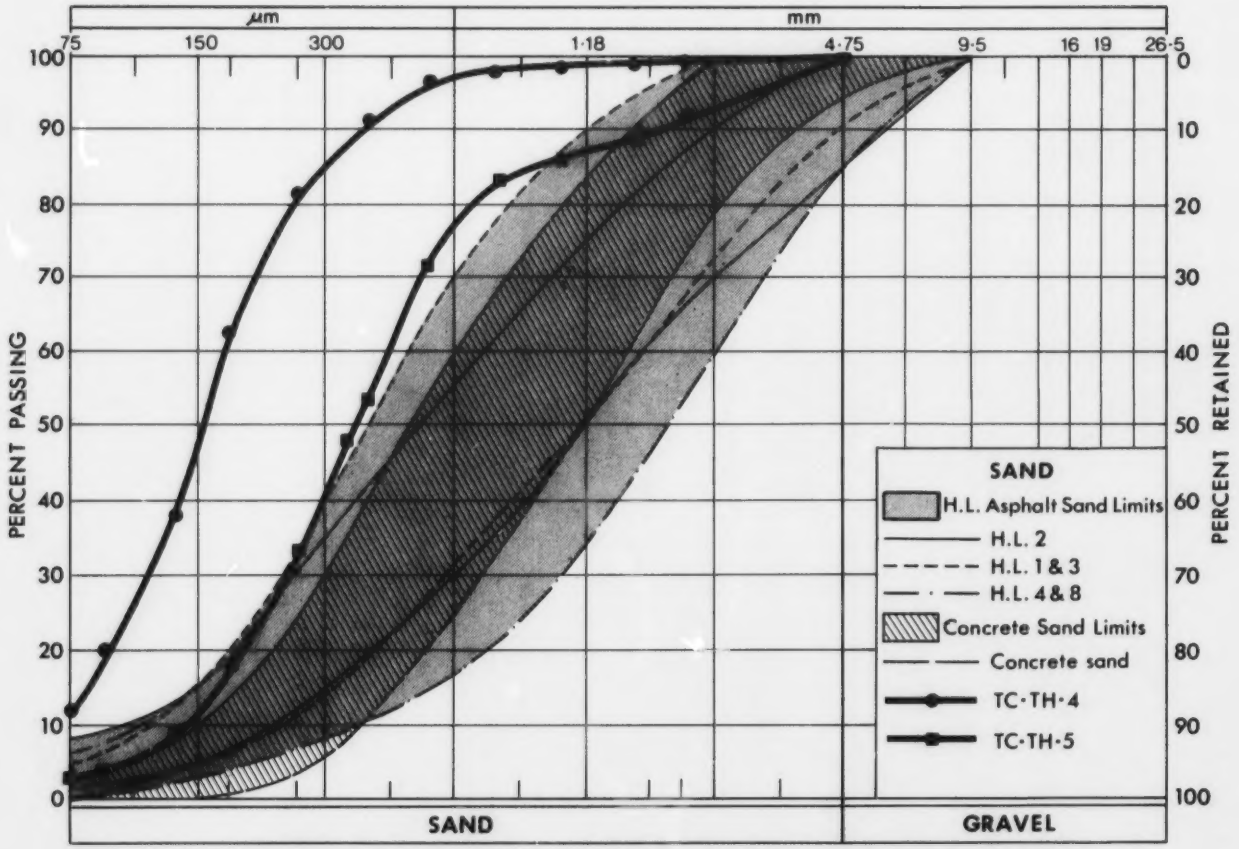


FIGURE 3b. AGGREGATE GRADING CURVES, TOWN OF NEW TECUMSETH.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from MTO Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix B — Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Aggregate Abrasion Value: This test directly measures the resistance of aggregate to abrasion with silica sand and a steel disk. The higher the value, the lower the resistance to abrasion. For high quality asphalt surface course uses, values of less than 6 are desirable.

Alkali-aggregate reaction: A chemical reaction between the alkalies of Portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Beneficiation: Beneficiation of aggregates is a process or combination of processes which improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing or classification. Heavy media separation, jigging or application of special crushers (e.g., "cage mill") are usually considered processes of beneficiation.

Blending: Required in cases of extreme coarseness, fineness or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Bulk Relative Density: An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative density aggregates (less than about 2.5) are often nondurable for many aggregate uses.

Cambrian: The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

Crushable aggregate: Unprocessed gravel containing a minimum of 35% coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20% greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability,

permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granular base course: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

Hot-laid (or asphaltic) aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (HL 1, 3 and 4), or as binder course (HL 2 and 8) used to bind the surface course to the underlying granular base course.

Lithology: The description of rocks on the basis of such characteristics as colour, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Los Angeles Abrasion and Impact Test: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Values less than about 35% indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45% indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible to freezing and thawing will usually break down and give high losses in this test. Values greater than about 12 to 15% indicate potential problems for concrete and asphalt coarse aggregate.

Meltwater channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic era: One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic examination: Individual aggregate particles in a sample are divided into categories good, fair, poor, and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Polished Stone Value: This test measures the frictional properties of aggregates after 6 hours of abrasion and polishing with an emery abrasive. The higher the PSV, the higher the frictional properties of the aggregate. Values less than 45 indicate marginal frictional properties, while values greater than 55 indicate excellent frictional properties.

Possible resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

Precambrian: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Silurian: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers, consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Subaqueous Fan (SF): Subaqueous fans are formed within or near the mouths of meltwater conduits when sediment laden meltwaters are discharged into a standing body of water. The geometry of the resulting deposit is fan or lobe shaped. Several of these lobes may be joined together to form a larger, continuous sedimentary body. Internally, subaqueous fans consist of stratified sands and gravels which may exhibit wide variations in grain size distribution. As these features were deposited under glacial lake waters, silt and clay which settled out of these lakes may be associated in varying amounts with these deposits. The variability of the sediments and presence of fines are the main extractive problems associated with these deposits.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have

generally low value because of the presence of excess silt- and clay-sized material. There are few large post-glacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario, such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

Appendix D — Geology of Bedrock Deposits

The purpose of this appendix is to familiarize the reader with the general bedrock geology of southern Ontario (Figure D1), and the potential uses of the various bedrock formations where known. The reader is cautioned against using this information for more specific purposes. The stratigraphic chart (Figure D2) is intended only to illustrate the stratigraphic sequences in particular geographic areas and should not be used as a regional correlation table.

The following description is arranged in ascending stratigraphic order, on a group and formation basis. Precambrian rocks are not discussed. Additional stratigraphic information is included for some formations where necessary. The publications and maps of the Ontario Geological Survey and the Geological Survey of Canada should be referred to for more detailed information. The composition, thickness and uses of the formations are discussed. If a formation may be suitable for use as aggregate and aggregate suitability test data is available, the data has been included in the form of ranges. The following short forms have been used in presenting this data: PSV = Polished Stone Value, AAV = Aggregate Abrasion Value, $MgSO_4$ = Magnesium Sulphate Soundness Test (loss in percent), LA = Los Angeles Abrasion and Impact Test (loss in percent), Absn = Absorption (percent), BRD = Bulk Relative Density, PN (Asphalt & Concrete) = Petrographic Number for Asphalt and Concrete use.

The ranges are intended as a guide only and care should be exercised in extrapolating the information to specific situations. Aggregate suitability test data has been provided by the Ontario Ministry of Transportation.

Covey Hill Formation (Cambrian)

STRATIGRAPHY: lower formation of the Potsdam Group. COMPOSITION: interbedded noncalcareous feldspathic conglomerate and sandstone. THICKNESS: 0 to 45 feet (0 to 14 m). USES: has been quarried for aggregate in South Burgess Township, Leeds County.

Nepean Formation (Cambro-Ordovician)

STRATIGRAPHY: upper formation of the Potsdam Group. COMPOSITION: thin-bedded to massive quartz sandstone with some conglomerate interbeds and rare shaly partings. THICKNESS: 0 to 100 feet (0 to 30 m). USES: suitable as dimension stone; quarried at Philipsville and Forfar for silica sand; alkali-silica reactive in Portland cement concrete. AGGREGATE SUITABILITY TESTING: PSV = 54-68, AAV = 4-15, $MgSO_4$ = 9-32, LA = 44-90, Absn = 1.6-2.6, BRD = 2.38-2.50, PN (Asphalt & Concrete) = 130-140.

March Formation (Lower Ordovician)

STRATIGRAPHY: lower formation of the Beekmantown Group. COMPOSITION: interbedded quartz sandstone, dolomitic quartz sandstone, sandy dolostone and dolostone. THICKNESS: 60 to 197 feet (18 to 60 m). USES: quarried extensively for aggregate in area of subcrop and outcrop; alkali-silica reactive in Portland cement concrete; lower part of formation is an excellent source of skid-resistant aggregate; suitable for use as facing stone and paving stone. AGGREGATE SUITABILITY TESTING: PSV = 55-60, AAV = 4-6, $MgSO_4$ = 1-17, LA = 15-38, Absn = 0.5-0.9, BRD = 2.61-2.65, PN (Asphalt & Concrete) = 110-150.

Oxford Formation (Lower Ordovician)

STRATIGRAPHY: upper formation of the Beekmantown Group. COMPOSITION: thin- to thick-bedded, microcrystalline to medium-crystalline, grey dolostone with thin shaly interbeds. THICKNESS: 200 to 335 feet (61 to 102 m). USES: quarried in the Brockville and Smith Falls areas and south of Ottawa for use as aggregate. AGGREGATE SUITABILITY TESTING: PSV = 47-48, AAV = 7-8, $MgSO_4$ = 1-4, LA = 18-23, Absn = 0.7-0.9, BRD = 2.74-2.78, PN (Asphalt & Concrete) = 105-120.

Rockcliffe Formation (Middle Ordovician)

STRATIGRAPHY: divided into lower member and upper (St. Martin) member. COMPOSITION: interbedded quartz sandstone and shale; interbedded shaly bioclastic limestone and shale predominating in upper member to the east. THICKNESS: 0 to 410 feet (0 to 125 m). USES: upper member has been quarried east of Ottawa for aggregate; lower member has been used as crushed stone; some high purity limestone beds in upper member may be suitable for use as fluxing stone and in lime production. AGGREGATE SUITABILITY TESTING: PSV = 58-63, AAV = 10-11, $MgSO_4$ = 12-40, LA = 25-28, Absn = 1.8-1.9, BRD = 2.55-2.62, PN (Asphalt & Concrete) = 122-440.

Shadow Lake Formation (Middle Ordovician)

STRATIGRAPHY: in eastern Ontario, the basal unit of the Ottawa Group; in central Ontario, overlain by the Simcoe Group. COMPOSITION: in eastern Ontario, silty and sandy dolostone with shale partings and minor interbeds of sandstone; in central Ontario,

conglomerates, sandstones and shales. THICKNESS: in eastern Ontario, 7 to 10 feet (2 to 3 m); in central Ontario, 0 to 40 feet (0 to 12 m). USES: potential source of decorative stone; very limited value as aggregate source.

Gull River Formation (Middle Ordovician)

STRATIGRAPHY: part of the Simcoe Group (central Ontario) and Ottawa Group (eastern Ontario). In central and eastern Ontario, the formation is subdivided into upper and lower members; west of Lake Simcoe, it is presently subdivided into upper, middle and lower members. COMPOSITION: in central and eastern Ontario, the lower member consists of alternating units of limestone, dolomitic limestone and dolostone, the upper member consists of thin-bedded limestones with thin shale partings; west of Lake Simcoe, the lower member is thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone, whereas the upper and middle members are dense microcrystalline limestones with argillaceous dolostone interbeds. THICKNESS: 23 to 204 feet (7 to 62 m). USES: quarried in the Lake Simcoe, Kingston, Ottawa and Cornwall areas for crushed stone; rock from certain layers in eastern and central Ontario has proven to be alkali-reactive when used in Portland cement concrete (alkali-carbonate reaction). AGGREGATE SUITABILITY TESTING: PSV = 41-49, AAV = 8-12, $MgSO_4$ = 3-13, LA = 18-28, Absn = 0.3-0.9, BRD = 2.68-2.73, PN (Asphalt & Concrete) = 100-153.

Bobcaygeon Formation (Middle Ordovician)

STRATIGRAPHY: part of the Simcoe Group (central Ontario) and the Ottawa Group (eastern Ontario), subdivided into upper, middle and lower members; members in eastern and central Ontario are approximately equivalent. COMPOSITION: homogeneous, massive to thin-bedded fine-crystalline limestone with numerous shaly partings in the middle member. THICKNESS: 80 to 285 feet (24 to 87 m). USES: quarried at Brechin, Marysville and in the Ottawa area for crushed stone; generally suitable for use as granular base course aggregate; rock from certain layers has been found to be alkali-reactive when used in Portland cement concrete (alkali-silica reaction). AGGREGATE SUITABILITY TESTING: PSV = 47-51, AAV = 14-23, $MgSO_4$ = 1-40, LA = 18-32, Absn = 0.3-2.4, BRD = 2.5-2.69, PN (Asphalt & Concrete) = 100-320.

Verulam Formation (Middle Ordovician)

STRATIGRAPHY: part of Simcoe and Ottawa groups. COMPOSITION: fossiliferous, pure to argillaceous limestone interbedded with calcareous shale. THICKNESS: 105 to 230 feet (32 to 70 m). USES: quarried at Picton and Bath for use in cement manufacture; quarried for aggregate in Mara Township, Simcoe County and in the Belleville-Kingston area; may be unsuitable for use as aggregate in some areas because of its high shale content. AGGREGATE SUITABILITY TESTING: PSV = 43-44, AAV = 9-13, $MgSO_4$ = 4-45, LA = 22-29, Absn = 0.4-2.1, BRD = 2.59-2.70, PN (Asphalt & Concrete) = 120-255.

Lindsay Formation (Middle and Upper Ordovician)

STRATIGRAPHY: part of Simcoe and Ottawa groups; in eastern Ontario, it is divisible into an unnamed lower member and the Eastview Member; in central Ontario, it is divisible into the Collingwood Member (equivalent to portions of the Eastview Member) and a lower member. COMPOSITION: in eastern Ontario, the lower member is interbedded, very fine- to coarse-crystalline limestone with undulating shale partings and interbeds of dark grey calcareous shale, whereas the Eastview Member is an interbedded dark grey to dark brown calcareous shale and very fine- to fine-crystalline, petroliferous limestone; in central Ontario, Collingwood Member is a black, calcareous shale whereas the lower member is a very fine- to coarse-crystalline, thin-bedded limestone with very thin, undulating shale partings. THICKNESS: 82 to 200 feet (25 to 61 m). USES: in eastern Ontario, the lower member is used extensively for aggregate production; in central Ontario, it is quarried at Picton, Ogden Point and Bowmanville for cement; may be suitable or unsuitable for use as concrete and asphalt aggregate. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 2-47, LA = 20-28, Absn = 0.4-1.3, BRD = 2.64-2.70, PN (Asphalt & Concrete) = 110-215.

Blue Mountain and Billings Formations (Upper Ordovician)

STRATIGRAPHY: in central Ontario, Blue Mountain Formation includes the upper and middle members of the former Whitby Formation; in eastern Ontario, Billings Formation is equivalent to part of the Blue Mountain Formation. COMPOSITION: the Blue Mountain Formation is blue-grey, noncalcareous shale; Billings Formation is dark grey to black, noncalcareous to slightly calcareous, pyritiferous shale with dark grey limestone laminae and grey siltstone interbeds. THICKNESS: Blue Mountain Formation - 140 to 200 feet (43 to 61 m); Billings Formation - 0 to 205 feet (0 to 62 m). USES: Billings Formation may be a suitable source for structural clay products and expanded aggregate; Blue Mountain Formation may be suitable for structural clay products.

Georgian Bay and Carlsbad Formations (Upper Ordovician)

COMPOSITION: in central Ontario, the Georgian Bay Formation is composed of interbedded limestone and shale; in eastern Ontario, the Carlsbad Formation is composed of interbedded shale, siltstone and bioclastic limestone; THICKNESS: Georgian Bay Formation - 300 to 560 feet (91 to 170 m); Carlsbad Formation - 0 to

610 feet (0 to 186 m). USES: Georgian Bay Formation is used by several producers in Metropolitan Toronto area to produce brick and structural tile, as well as for making Portland cement; at Streetsville, expanded shale was used in the past to produce lightweight aggregate; Carlsbad Formation is used as a source material for brick and tile manufacturing, has potential as a lightweight expanded aggregate.

Queenston Formation (Upper Ordovician)

COMPOSITION: red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. THICKNESS: 400 to 500 feet (122 to 152 m). USES: there are several large quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa; all extract shale for brick manufacturing; the Queenston Formation is the most important source material for brick manufacture in Ontario.

Whirlpool Formation (Lower Silurian)

STRATIGRAPHY: lower formation in the Cataract Group in the Niagara Peninsula and the Niagara Escarpment as far north as Duntroon. COMPOSITION: massive, medium- to coarse-grained, argillaceous white to light grey quartz sandstone with thin grey shale partings. THICKNESS: 0 to 25 feet (0 to 8 m). USES: building stone, flagstone.

Manitoulin Formation (Lower Silurian)

STRATIGRAPHY: part of the Cataract Group, occurs north of Stoney Creek. COMPOSITION: thin-bedded, blue-grey to buff brown dolomitic limestones and dolostones. THICKNESS: 0 to 75 feet (0 to 23 m). USES: extracted for crushed stone in St. Vincent Township, Grey County, and for decorative stone on Manitoulin Island. AGGREGATE SUITABILITY TESTING: no data.

Cabot Head Formation (Lower Silurian)

STRATIGRAPHY: part of the Cataract Group, occurs throughout southern Ontario, south and north of the Niagara Escarpment. COMPOSITION: green, grey and red shales. THICKNESS: 50 to 60 feet (15 to 18 m); USES: potential source of coated lightweight aggregate and raw material for use in manufacture of brick and tile; lack of suitable exposures has limited its use.

Grimsby Formation

STRATIGRAPHY: upper formation of the Cataract Group, is identified on the Niagara Peninsula as far north as Clappison's Corners. COMPOSITION: interbedded sandstone and shale, mostly red. THICKNESS: 0 to 50 feet (0 to 15 m). USES: no present uses.

Thorold Formation (Middle Silurian)

STRATIGRAPHY: lower formation in the Clinton Group on the Niagara Peninsula. COMPOSITION: thick-bedded quartz sandstone. THICKNESS: 7 to 10 feet (2 to 3 m). USES: no present uses.

Neagha Formation (Middle Silurian)

STRATIGRAPHY: part of the Clinton Group on the Niagara Peninsula. COMPOSITION: dark grey to green shale with minor interbedded limestone. THICKNESS: 0 to 5 feet (0 to 2 m). USES: no present uses.

Dyer Bay Formation (Middle Silurian)

STRATIGRAPHY: lower formation in the Clinton Group on Manitoulin Island and northernmost Bruce Peninsula. COMPOSITION: highly fossiliferous, impure dolostone. THICKNESS: 0 to 20 feet (0 to 6 m). USES: no present uses.

Wingfield Formation (Middle Silurian)

STRATIGRAPHY: part of the Clinton Group on Manitoulin Island and northernmost Bruce Peninsula. COMPOSITION: olive green to grey shale with dolostone interbeds. THICKNESS: 0 to 36 feet (0 to 11 m). USES: no present uses.

St. Edmund Formation (Middle Silurian)

STRATIGRAPHY: part of the Clinton Group on Manitoulin Island and northernmost Bruce Peninsula, upper portion previously termed the Mindemoya Formation. COMPOSITION: pale grey to buff brown, micro- to medium-crystalline, thin- to medium-bedded dolostone. THICKNESS: 0 to 85 feet (0 to 26 m). USES: quarried for fill and crushed stone on Manitoulin Island. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 1-2, LA = 19-21, Absn = 0.6-0.7, BRD = 2.78-2.79, PN (Asphalt & Concrete) = 105.

Fossil Hill and Reynales Formations (Middle Silurian)

STRATIGRAPHY: part of Clinton Group; Fossil Hill Formation occurs in the northern part of the Niagara Escarpment and is approximately equivalent in part, to the Reynales Formation which occurs on the Niagara Peninsula and the Escarpment, as far north as the Forks of the Credit. COMPOSITION: Fossil Hill Formation is fine- to coarse-crystalline dolostone with high silica content; Reynales Formation is thin- to thick-bedded shaly dolostone and dolomitic limestone. THICKNESS: Fossil Hill Formation - 20 to 85 feet (6 to 26 m); Reynales Formation - 0 to 10 feet (0 to 3 m). USES: both formations quarried for aggregate with overlying Amabel and Lockport formations. AGGREGATE SUITABILITY TESTING: (Fossil Hill Formation on Manitoulin Island) $MgSO_4$ = 41, LA = 29, Absn = 4.1, BRD = 2.45, PN (Asphalt & Concrete) = 370.

Irondequoit Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group on the Niagara Peninsula south of Waterdown.

COMPOSITION: massive, coarse-crystalline crinoidal limestone. THICKNESS: 0 to 7 feet (0 to 2 m). USES: not significantly utilized.

Rochester Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group along the Niagara Peninsula. COMPOSITION: black to dark grey calcareous shale with numerous limestone lenses. THICKNESS: 15 to 60 feet (5 to 18 m). USES: not significantly utilized. AGGREGATE SUITABILITY TESTING: PSV = 69, AAV = 17, $MgSO_4$ = 95, LA = 19, Absn = 2.2, BRD = 2.67, PN (Asphalt & Concrete) = 400.

Decew Formation (Middle Silurian)

STRATIGRAPHY: part of Clinton Group south of Waterdown along the Niagara Peninsula. COMPOSITION: sandy to shaly dolomitic limestone and dolostone. THICKNESS: 0 to 15 feet (0 to 5 m). USES: too shaly for high quality uses, but is quarried along with Lockport Formation in places. AGGREGATE SUITABILITY TESTING: PSV = 67, AAV = 15, $MgSO_4$ = 55, LA = 21, Absn = 2.2, BRD = 2.66, PN (Asphalt & Concrete) = 255.

Lockport and Amabel Formations (Middle Silurian)

STRATIGRAPHY: Lockport Formation occurs from Waterdown to Niagara Falls, subdivided into 3 formal members: Gasport, Goat Island and Eramosa members and an informal member (the "Vinemount shale beds"); the stratigraphically equivalent Amabel Formation, found from Waterdown to Cockburn Island, is subdivided into Lions Head, Wiarton/Colpoy Bay and Eramosa members. COMPOSITION: Lockport Formation is thin- to massive-bedded, fine- to medium-crystalline dolostone; Amabel Formation is thin-bedded to massive, medium-crystalline dolostone with reef facies near Georgetown and on the Bruce Peninsula. THICKNESS: (Lockport/ Amabel) 10 to 130 feet (3 to 40 m). USES: both formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. AGGREGATE SUITABILITY TESTING: PSV = 36-49, AAV = 10-17, $MgSO_4$ = 2-6, LA = 25-32, Absn = 0.4-1.54, BRD = 2.61-2.81, PN (Asphalt & Concrete) = 100-105.

Guelph Formation (Middle Silurian)

STRATIGRAPHY: exposed on the Niagara Escarpment from the Niagara River to the tip of the Bruce Peninsula, mostly present in the subsurface of southwestern Ontario. COMPOSITION: micro-crystalline to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies of high chemical purity. THICKNESS: 100 to 170 feet (30 to 52 m). USES: some areas appear soft and unsuitable for use in the production of load-bearing aggregate; this unit requires additional testing to fully establish its aggregate suitability; main use is for dolomitic lime for cement manufacture; quarried near Hamilton and Guelph.

Salina Formation (Upper Silurian)

STRATIGRAPHY: present in the subsurface of southwestern Ontario; rarely exposed at the surface. COMPOSITION: grey and maroon shale, brown dolostone and, in places, salt, anhydrite and gypsum; consists predominantly of evaporitic rich material with up to eight units identifiable. THICKNESS: 370 to 600 feet (113 to 183 m). USES: gypsum mines at Hagersville, Caledonia and Drumbo; salt is mined at Goderich and Windsor, and is produced from brine wells at Amherstburg, Windsor and Sarnia.

Bertie and Bass Islands Formations (Upper Silurian)

STRATIGRAPHY: Bertie Formation found in southern Niagara Peninsula; Bass Islands Formation, the Michigan Basin equivalent of the Bertie Formation, does not significantly outcrop in Ontario but is present in the subsurface in southwestern Ontario; Bertie Formation represented by Oatka, Falkirk, Scajaquanda, Williamsville, and Akron members. COMPOSITION: medium- to massive-bedded, micro-crystalline, brown dolostone with shaly partings. THICKNESS: 45 to 160 feet (14 to 49 m). USES: quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville and Dunnville; shaly intervals are unsuitable for use as high-specification aggregate because of low freeze-thaw durability; has also been extracted for lime. AGGREGATE SUITABILITY TESTING: PSV = 46-49, AAV = 8-11, $MgSO_4$ = 4-19, LA = 14-23, Absn = 0.8-2.8, BRD = 2.61-2.78, PN (Asphalt & Concrete) = 102-120.

Oriskany Formation (Lower Devonian)

STRATIGRAPHY: basal Devonian clastic unit, found in Niagara Peninsula. COMPOSITION: thick- to massive-bedded, coarse-grained, grey-yellow sandstone. THICKNESS: 0 to 15 feet (0 to 5 m). USES: has been quarried for silica sand, building stone and armour stone; may be acceptable for use as rip rap, and well cemented varieties may be acceptable for some asphaltic products. AGGREGATE SUITABILITY TESTING: (of a well cemented variety of the formation) PSV = 64, AAV = 6, $MgSO_4$ = 2, LA = 29, Absn = 1.2-1.3, BRD = 2.55, PN (Asphalt & Concrete) = 107.

Bois Blanc Formation (Lower Devonian)

STRATIGRAPHY: Springvale Sandstone Member forms the lower portion of formation. COMPOSITION: a cherty limestone with shale partings and minor interbedded dolostones; Springvale Sandstone Member is a medium- to coarse-grained, green glauconitic sandstone with interbeds of limestone, dolostone and brown chert. THICKNESS: 10 to 130 feet (3 to 40 m). USES: quarried at Hagersville, Cayuga and Port Colborne for crushed stone; material generally un-

suitable for concrete aggregate because of high chert content. AGGREGATE SUITABILITY TESTING: PSV = 48-53, AAV = 3-7, $MgSO_4$ = 3-18, LA = 15-22, Absn = 1.3-2.8, BRD = 2.50-2.70, PN (Asphalt & Concrete) = 102-290.

Onondaga Formation (Middle Devonian)

STRATIGRAPHY: correlated to part of the Detroit River Group; occurs on the Niagara Peninsula from Simcoe to Niagara Falls; contains the Edgecliff, Clarence, and Moorehouse members. COMPOSITION: medium-bedded, fine- to coarse-grained, dark grey-brown or purplish brown, variably cherty limestone. THICKNESS: 60 to 82 feet (18 to 25 m) USES: quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne; high chert content makes much of the material unsuitable for use as concrete aggregate and asphaltic concrete; has been used as a raw material in cement manufacture. AGGREGATE SUITABILITY TESTING: (Clarence and Edgecliff members) $MgSO_4$ = 1-6, LA = 16.8-22.4, Absn = 0.5-1.1, PN (Asphalt & Concrete) = 190-276.

Amherstburg Formation (Middle Devonian)

STRATIGRAPHY: part of Detroit River Group; correlated to Onondaga Formation in Niagara Peninsula; contains Sylvania Sandstone Member and Formosa Reef Limestone. COMPOSITION: bituminous, bioclastic, stromatoporoid-rich limestone and dolostone with grey chert nodules; Formosa Reef Limestone is high purity (calcium-rich) limestone; Sylvania Sandstone Member is quartz sandstone. THICKNESS: 0 to 165 feet (0 to 50 m); Formosa Reef Limestone up to 85 feet (26 m). USES: cement manufacture, agricultural lime, aggregate. AGGREGATE SUITABILITY TESTING: PSV = 57, AAV = 19, $MgSO_4$ = 9-35, LA = 26-52, Absn = 1.1-6.4, BRD = 2.35-2.62, PN (Asphalt & Concrete) = 105-300.

Lucas Formation (Middle Devonian)

STRATIGRAPHY: part of the Detroit River Group in southwestern Ontario; includes the Anderdon Member which, in the Woodstock Beachville area, may constitute the bulk of the formation. COMPOSITION: light brown or grey-brown dolostone with bituminous laminations and minor chert; Anderdon Member consists of very high purity (calcium-rich) limestone. THICKNESS: 130 to 246 feet (40 to 75 m). USES: most important source of high-purity limestone in Ontario; used as calcium lime for metallurgical flux and for the manufacture of chemicals; rock of lower purity is used for cement manufacture, agricultural lime and aggregate; Anderdon Member is quarried at Amherstburg for crushed stone. AGGREGATE SUITABILITY TESTING: PSV = 46-47, AAV = 15-16, $MgSO_4$ = 2-60, LA = 22-47, Absn = 1.1-6.5, BRD = 2.35-2.40, PN (Asphalt & Concrete) = 110-160.

Dundee Formation (Middle Devonian)

STRATIGRAPHY: few natural outcrops, largely in the subsurface of southwestern Ontario. COMPOSITION: fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers and chert in some areas. THICKNESS: 50 to 100 feet (15 to 30 m). USES: quarried near Port Dover and on Pelee Island for crushed stone; used at St. Marys as a raw material for Portland cement. AGGREGATE SUITABILITY TESTING: $MgSO_4$ = 1-28, LA = 22-46, Absn = 0.6-6.8, PN (Asphalt & Concrete) = 125-320.

Marcellus Formation (Middle Devonian)

STRATIGRAPHY: subsurface unit, mostly found below Lake Erie and extending into the eastern U.S.A., pinches out in the Port Stanley area. COMPOSITION: black, bituminous shales. THICKNESS: 0 to 15 feet (0 to 5 m). USES: no present uses.

Bell Formation (Middle Devonian)

STRATIGRAPHY: lowest formation of the Hamilton Group, no outcrop in Ontario. COMPOSITION: soft blue and grey calcareous shale. THICKNESS: 0 to 30 feet (0 to 9 m). USES: no present uses.

Rockport Quarry Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group; no outcrop in Ontario. COMPOSITION: grey-brown, very fine-grained limestone with occasional shale layers. THICKNESS: 0 to 20 feet (0 to 6 m). USES: no present uses.

Arkona Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: blue-grey, plastic, clay shale with occasional thin and laterally discontinuous limestone lenses. THICKNESS: 15 to 120 feet (5 to 37 m). USES: has been extracted at Thedford and near Arkona for the production of drainage tile.

Hungry Hollow Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: grey crinoidal limestone and soft, fossiliferous calcareous shale. THICKNESS: 0 to 6 feet (0 to 2 m). USES: suitable for some crushed stone and fill with selective quarrying. AGGREGATE SUITABILITY TESTING: No data.

Widder Formation (Middle Devonian)

STRATIGRAPHY: part of the Hamilton Group. COMPOSITION: mainly soft, grey, fossiliferous calcareous shale interbedded with blue-grey, fine-grained fossiliferous limestone. THICKNESS: 0 to 45 feet (0 to 14 m). USES: no present uses.

Ipperwash Formation (Middle Devonian)

STRATIGRAPHY: upper formation of the Hamilton Group; very limited distribution. COMPOSITION: medium- to coarse-grained, grey-brown, bioclastic limestone. THICKNESS: 5 to 45 feet (2 to 14 m). USES: no present uses.

Kettle Point Formation (Upper Devonian)

STRATIGRAPHY: occurs in a band between Sarnia and Erieau; small part overlain by Port Lambton Group rocks in extreme northwest. COMPOSITION: black, highly fissile, organic-rich shale with minor interbeds of grey-green silty shale. THICKNESS: 0 to 200 feet (0 to 61 m). USES: possible source of fill; possible source of material for use as sintered lightweight aggregate.

Bedford Formation (Upper Devonian)

STRATIGRAPHY: lower formation of the Port Lambton Group. COMPOSITION: soft, grey shale. THICKNESS: 0 to 108 feet (0 to 33 m). USES: no present uses.

Berea Formation (Upper Devonian)

STRATIGRAPHY: middle formation of the Port Lambton Group; not known to occur at surface in Ontario. COMPOSITION: grey, fine- to medium-grained sandstone, often dolomitic and interbedded with grey shale and siltstone. THICKNESS: 0 to 197 feet (0 to 60 m). USES: no present uses.

Sunbury Formation (Upper Devonian)

STRATIGRAPHY: upper formation of the Port Lambton Group; not known to occur at surface in Ontario. COMPOSITION: black shale. THICKNESS: 0 to 66 feet (0 to 20 m). USES: no present uses.

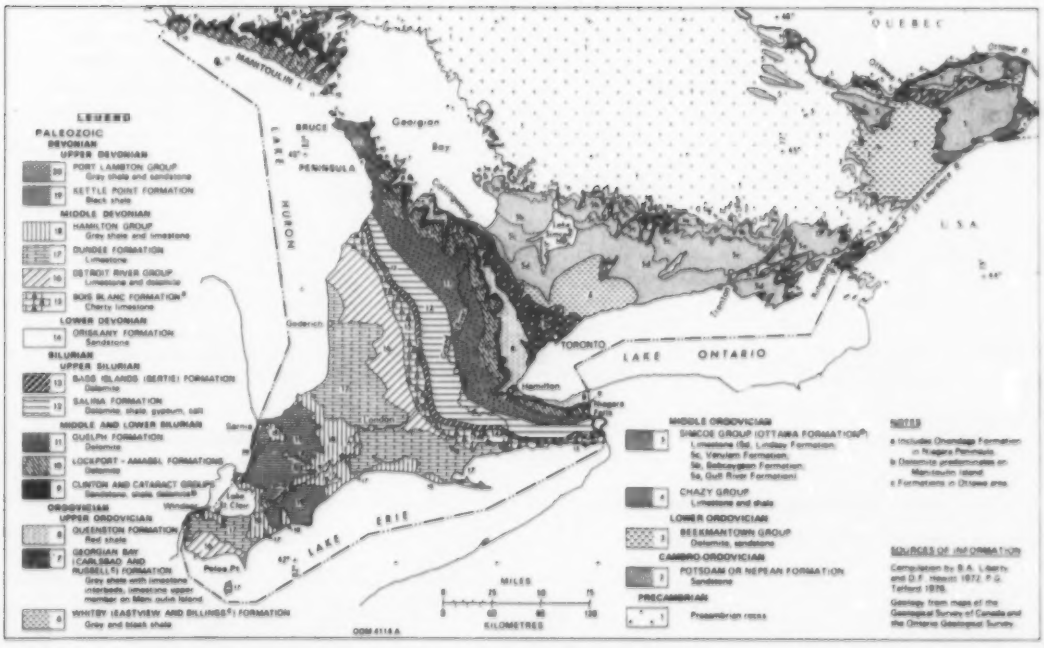

Figure D1. Bedrock geology of southern Ontario.

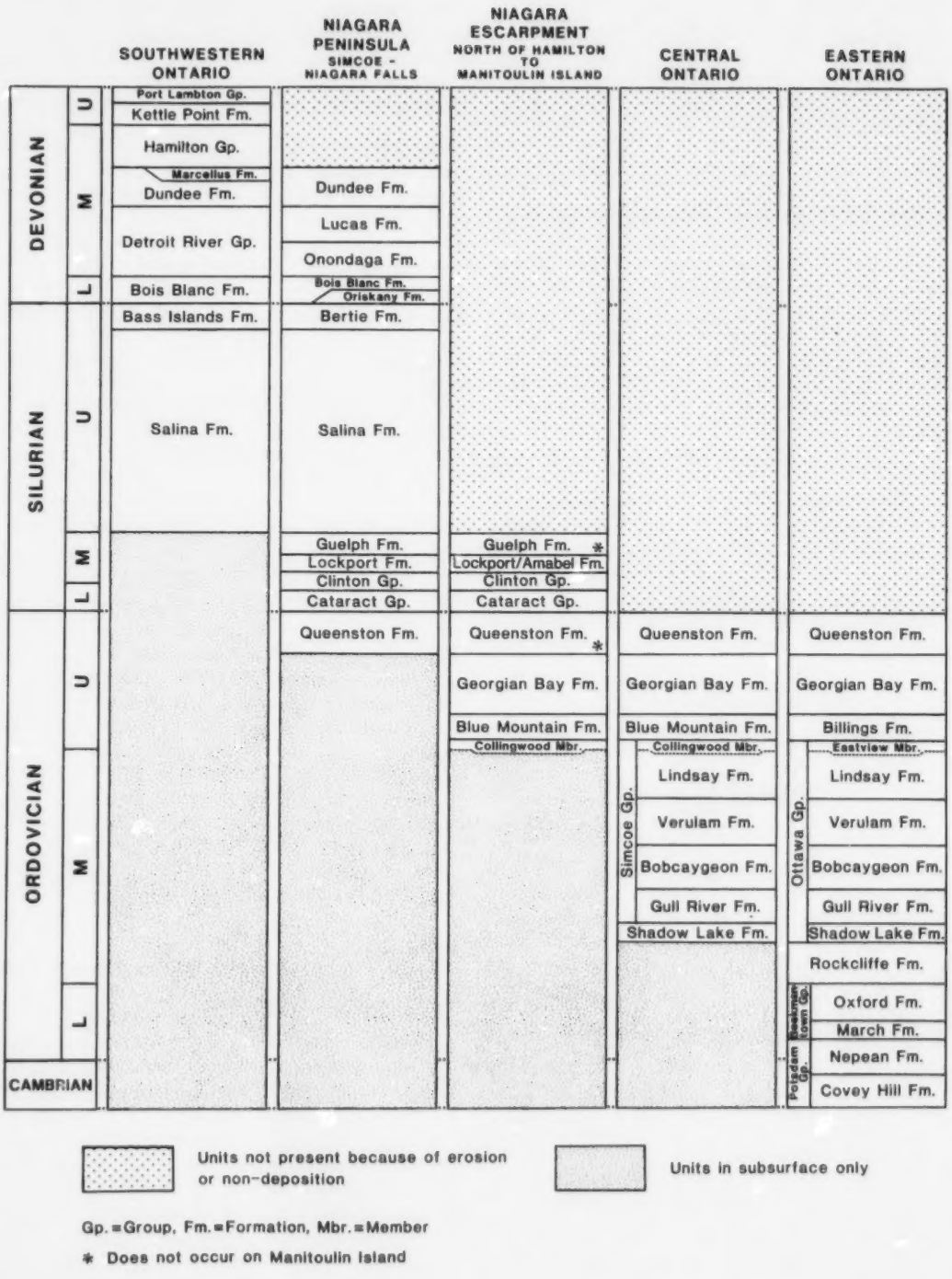

Figure D2. Exposed Paleozoic stratigraphic sequences in southern Ontario
(adapted from: Bezys, R. K. and Johnson, M.D. 1988. The geology of the Paleozoic formations utilized by the limestone industry of Ontario; The Canadian Mining and Metallurgical Bulletin, v.81, no.912, p.49-58).

Appendix E — Aggregate Quality Test Specifications

Four types of aggregate quality tests are often performed by the Ontario Ministry of Transportation on sampled material. A description of Table E1 and the specification limits for each test are given in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the four major tests listed in this appendix can be used to determine the suitability of an aggregate. The tests are performed by the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Los Angeles abrasion and impact test: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Values less than about 35% indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45% indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible to freezing and thawing will usually break down and give high losses in this test. Values greater than about 12 to 15% indicate potential problems for concrete and asphalt coarse aggregate.

Petrographic examination: Individual aggregate particles in a sample are divided into categories good, fair, poor and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

TABLE E1. SELECTED QUALITY REQUIREMENTS FOR MAJOR AGGREGATE PRODUCTS.

	TYPE OF TEST				
	COARSE AGGREGATE				FINE AGGREGATE
TYPE OF MATERIAL	Petrographic Number Maximum	Magnesium Sulphate Soundness Maximum % Loss	Absorption Maximum %	Los Angeles Abrasion Maximum % Loss	Magnesium Sulphate Soundness Maximum % Loss
Granular Base A	200	-	-	60	-
16 mm Crushed Type 'A'	160	-	-	35	-
16 mm Crushed Type 'B'	200	-	-	60	-
Granular Subbase B	250	-	-	-	-
Granular Subbase C	250	-	-	-	-
Granular Subbase D	-	-	-	-	-
Hot Mix - HL 1	100	5	1.0	15	16
Hot Mix - HL 2	-	-	-	-	20
Hot Mix - HL 3	135	12	1.75	35	16
Hot Mix - HL 4	160	12	2.0	35	20
Hot Mix - HL 8	160	15	2.0	35	20
Structural Concrete and Concrete Base	140	12	2.0	35	16
Pavement Concrete and Exposed Structure Deck	125	12	2.0	35	16

(Ministry of Transportation Forms 1002, 1003 and 1010)

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

MAPS
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CARTES
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